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The Validity of Okun's law – A Global Analysis

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Content

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1 Introduction

In the paper "*Potential GNP: Its Measurement and Significance*", American economist Arthur Okun documents an empirical relationship between unemployment and output. This empirical finding has been replicated by many other researchers who confirmed the same finding which led to Okun's law becoming a component of macroeconomics. Okun's law states that an additional 1-percentage-point increase in real GNP change is correlated with a 0.3 percentage point decrease in the unemployment rate. This law is based on a postwar period looking at quarter-to-quarter growth rate of the real GNP and quarter-to-quarter change in unemployment rate over the time period 1947 and 1960. Consequently, Okun's Law has become a component of most macroeconomic textbooks in the same way as the Phillips curve. Okun's relationship describes how positive changes in GDP are associated with negative changes in unemployment. These models seem to suggest that unemployment can be reduced by means of increasing the GDP. Nevertheless, researchers refer to these models as "rule of thumbs" instead of actual economic theories since Okun's law is deemed as more of a correlation rather than a structural feature or economic concept based on theory.

Contemporary economists have started to doubt the consistency of Okun's law. Researcher Robert J. Gordon concludes that Okun's law was only roughly correct for the period between 1954 and 1986 (Gordon, 2010). Gordon claims that after 1986, a structural shift has occurred after which productivity and hours worked behaved different to fluctuations in real GDP. The researcher also heavily critiques the conventional research method in modern macroeconomics that serve to separate trend from cycle, stating that:

"No paper can discuss or analyze cyclical gaps in output, hours, productivity, or employment until they have done their preliminary homework of determining the underlying growth trends from which the "gaps" are a deviation. An important conclusion of this paper is that the standard statistical technique in modern macroeconomics to separate trend from cycle, the Hodrick-Prescott (HP) filter (and its near-equivalent, the band-pass filter) generates trends that are implausibly sensitive to observed business cycles. A H-P growth trend for aggregate hours in 2009-10 is negative by 2 percent per annum, an implausible conclusion in

the context of ongoing growth in the working-age population at a rate of about 1.2 percent per year.".

The HP filter is the backbone of the "gaps" version of Okun's law, which this paper will dive deeper into later. This filter is used to smooth the unemployment and output series in order to estimate the natural unemployment rate and the potential output level.

Another critique of Okun's law is its instability over time. In the paper "An Unstable Okun's law, Not the Best Rule of Thumb", researchers Meyer and Tasci (2012) illustrate that Okun's law is not a suitable rule of thumb. The researchers argue that the relationship between unemployment and output is dynamically changing, stating that:

"- if one agrees with the idea that unemployment even in good times cannot go down to zero because of normal labor market churn, then there is no reason to expect a significant decline from this level in the unemployment rate as the economy experiences a long stretch of expansion.".

The researchers do admit that there is a relationship between output and unemployment, but fluctuations in macroeconomy cause that relationship to be non-linear.

These critiques of Okun's law matter when it comes to interpreting the relevance of Okun's relationship for labor market movements and macroeconomy policy. Okun's law is part of an agglomeration of textbook models that try to explain how changes in output affect the labor market. These models seem to suggest that demand stimulus can reduce unemployment. If empirical research indicates that Okun's law does not hold in other countries and thus is an unreliable relationship that does not bring any merit, it should not be taught as economic law but as a mere regression output that only holds for certain data points or as other researchers like to refer to it, a rule of thumb.

The main research question of this paper is as follows:

"Is Okun's law valid across countries under varying time frequencies?"

The goal of this research question is to analyze whether Okun's law holds for other countries and to estimate the magnitude of the relationship for three different time frequencies. Second is to explore whether Okun's law fits these countries better if we implement different time frequencies into the regression in which the moving average of output growth

is regressed on the moving average of unemployment rate change. This will be done through examining and analyzing OECD quarterly data on unemployment rate change and output growth from over 30 countries. Finally, this paper will analyze the relationship between GDP growth and employment change for certain industries. My research contributes to the contemporary macroeconomics literature by analyzing the validity and magnitude of Okun's law for a large amount of OECD countries from all over the world. Furthermore, this paper analyzes and compares Okun's relationship for these countries under three distinct time frequencies, annual, quarterly and 3-year, which enables us to assess the reliability of Okun's law as economic theory under different time dimensions.

This paper is divided into the following sections. Section 2 summarizes, and reviews previous literature done on the relationship between unemployment and output. Section 3 explains the methods and data chosen for the estimations. Section 4 displays the results derived from the estimations and the final section 5 contains a summary while providing concluding remarks.

2 Related Literature

A large number of papers have analyzed Okun's law in various ways with the goal of verifying or disputing the macroeconomic relationship. From looking at individual countries in short time periods to looking at global levels and long time periods. These papers find different results depending on the time periods looked at and the methods used. An example of this is the paper of (Attfield & Silverstone, 1997) which uses exactly the same dataset as another paper written by Martin Prachowny (1993) and found the coefficient to change substantially from 0.67 to 2.25. In this paper the researchers used a cointegrating relationship which drastically affected the results and look at the time period of 1967 to 1986. There exist several papers verifying Okun's law for different parts of the world during different times and a several papers disproving Okun's law for the same world regions looking at the same time periods.

I first take a look at the original paper from which Okun's law originated. In the original paper written by Okun, the researcher substantiates his theory quite extensively. The main research question of his paper is "*How much output can the (US) economy produce under conditions of full employment?*". Okun argues that the relevance from this research question stems from the fact that full employment is one of the main goals of policymakers and a target such as full employment has to be linked to a complementary full employment output. The distance between the target full employment output and the actual output is critical information when formulating monetary and fiscal policies (Okun, 1962). One major assumption of Okun's paper is the natural unemployment rate of 4%. This is the unemployment target on which this paper builds on and on which the estimation of potential GNP is based on. This is consequently also the part of the paper that gets most criticized by other researchers. 4% unemployment rate in 1960 has different effects and implications for the GNP in comparison to a 4% unemployment rate in 1990. Many researchers argue the difference here is caused by the shift in type of labor employed especially in the United States. One older paper written by Gary Smith (1974) revisited this macroeconomic relationship with the same criticism and states that there have been at least three major secular shifts, which could possibly have affected the magnitude of the relationship between employment and GNP changes. One shift is found in the changing composition of labor, with a higher proportion composed of white-collar employees who

seem to be more insulated from variations in the aggregate demand. Another shift has been in the ranks of the unemployed. The unemployed are becoming more composed of women and young men who traditionally work at lower wage rates than adult men. The researcher argues that since unemployed people are less productive than in previous years, it would take a smaller increase in demand to absorb their potential contributions. On the flipside, they may be structurally unemployed which means that a sizeable increase in GNP is needed to foster a sizeable demand for their skills. The third secular change would be an increase in confidence of employers to hold stable workforce numbers during recessions, as they have believed now that prolonged recessions can and will be avoided (Smith, 1974). In order to really assess the effect of these changes to the sensitivity of the relationship we have to look at estimations based on long time period datasets.

There is also an abundance of papers estimating Okun's relationship across countries. Sögner & Stiassny (2002) investigates Okun's relationship for 15 OECD countries while also inspecting for structural stability during the time period 1960 and 1999. The researchers conclude finding different estimates for different countries. They also conclude that the reaction time of employment to variations in GDP differs considerably across countries. The researchers also use Bayesian methods and Kalman filtering to investigate the structural stability of the estimated Okun coefficients. They find stable Okun relationships for the countries the United States, Italy, Canada, and Belgium. Furthermore, find unstable Okun relationships for the countries Switzerland, Sweden, the Netherlands, Japan, Great Britain, France, Finland, Denmark and Germany. The researchers are of the opinions that their analysis seem to suggest that for most countries, the changes in Okun coefficient values are caused mainly by larger reaction of employment on GDP variations. Their research seems to suggest that high levels of labor market protections are paired with lower reaction of employment to GDP variation (Sögner & Stiassny, 2002).

Research by Rahman & Mustafa (2017) also takes a look at OECD countries. The goal of this paper is to re-examine the validity of Okun's Law for 13 developed countries over the time period between 1970 and 2013. The paper makes use of lambda trace and lambda max tests which unveil a cointegrating correlation between real output growth and unemployment rate in all 13 chosen countries expect for Germany. This paper also presents dynamic OLS estimations which portray a comparatively distinct picture. By employing a bivariate error-

correction model, the resulting estimates reveal that Okun's relationship is altogether quite sound but only for the United States and South Korea. However, when it comes to the countries Canada, Finland, France, Australia, the United Kingdom, Sweden, New Zealand, The Netherlands, Italy and Japan, evidence for a valid Okun's law relatively weak. It seems as though for Germany that Okun's Law is outright invalid (Rahman & Mustafa, 2017).

Furthermore, research paper Lee (2000) likewise takes a look at 16 OECD countries in order to assess the robustness and validity of Okun's Law by exploiting heterogeneity in postwar data. They find that while Okun's relationship is valid for the majority of the chosen countries, there seems to be a lack of uniformity when it comes to the quantitative estimates. The researcher demonstrates that the choice of method and model greatly affects the responsiveness of the estimates. The methods implemented by this paper are the gap and first-difference specifications, and the used dataset is constructed through means of the Kalman filter which is built on top of the NAIRU framework, the Beveridge-Nelson decomposition procedure and HP filter. The results indicate that there is mixed evidence for asymmetric behaviour, however, there seems to be strong evidence for structural breaks, which according to the results took place during the 1970s. This is during the time that most of countries in this sample experienced significantly smaller GDP losses associated with the increase unemployment (Lee, 2000).

The paper by Zanin (2015) also analyses Okun's law for OECD countries but does so by examining the Okun coefficient by age cohorts. The data covers the time period of 1998 and 2012 of a substantial amount of OECD countries and divides the population into groups of males and females and five groups of ten-year age brackets. The researcher finds that younger people tend to be more vulnerable to economic shifts in comparison to older people. This was the case for both emerging and developed countries. This paper addresses the issue that was put forward by researcher Gary Smith who argued that there have been major secular shifts which can affect the stability of Okun's law over time. One of these major secular shift was the shift in the ranks of the unemployed, which became more composed of women and young men. This paper seems to confirm the thesis that the relationship between output and employment is more sensitive for these two groups in comparison to adult men, which results in higher Okun coefficients for these two groups (Zanin, 2015).

The paper Guisinger et al. (2015) takes a different approach by zooming in towards a state-level analysis while also providing a national-level estimation of Okun's law. They examine the time period between 1977 and 2012 estimate Okun's relationship for each of the U.S states. Afterwards, they examine the potential factors that could cause differences found in the Okun coefficients. They use the same approach as Arthur Okun by examining the deviations from the natural unemployment rate and production growth potential. They estimate the national Okun's coefficient to be equal to -2.03, which is consistent with most literature.

There have a been a great deal of researchers disputing the external validity of Okun's law for emerging economies. They argue that emerging economies are in different phases as compared to the post World War two United States economy. One paper written by Widarjono (2020) analyzes the asymmetry of Okun's law in the ASEAN-3 countries, which consists of Malaysia, the Philippines and Singapore. The research performs cointegrating tests by exploiting the asymmetric pooled mean group model and the non-linear autoregressive distributed lag model. The results of this research paper indicate cointegration between output and unemployment and proof for the asymmetry of Okun's law in all three countries under evaluation. This means that the direction of economic change has distinct effects on the unemployment rate change in these three nations. Furthermore, this research paper finds evidence for the fact that economic shrinkage has bigger negative effects on employment in comparison to the positive effect of economic growth on employment (Widarjono, 2020).

Furthermore, there exists a plethora of research papers examining the behaviour of Okun's relationship during certain phases of economies such as expansions and recessions. One such paper by Knotek (2007) makes the case that the volatility found in Okun's coefficient are connected to the various business cycles which affects the responsiveness of unemployment to total output variation heterogeneously during recessions and expansions. Using an extensive dataset containing US quarterly data from 1948 to 2007, this paper found smaller Okun coefficients during expansions and larger Okun coefficients during recessions than what Okun's law would have predicted. These results are found using an ordinary least squares estimation of both the dynamic and change methods used to analyze Okun's law. The researcher also makes use of rolling OLS estimations in order to examine various

patterns in the behaviour of Okun coefficients over time. They find that over time the correlations using lagged values of GDP growth have increased, while on the other hand the correlations using no lagged values has decreased. Another paper by Owyang and Sekhposyan (2012) also utilized US quarterly data from 1949 to 2011 in order to analyze the behaviour of Okun's relationship during US recessions. The researchers performs various methods such as gap, difference and dynamically distributed lag specifications and find that all three past US recessions during the time period of sample were subsequently followed by jobless recoveries. The unemployment had to have fallen more according to Okun's law, however this did not occur. On the other side of the coin, findings from the research paper Daly et al. (2014) proved that, during the global financial crisis of 2008, Okun's law behaved exceptionally similar in comparison to previously observed Okun coefficients during deep recessions. The results of this paper allows for the debate of Okun's law validity to live on and dismisses speculation regarding the end of Okun's law as overly exaggerated. This paper makes use of annual US data from 1959 to 2013, performing standard OLS regressions of the changes or difference method used when analyzing Okun's law. Finally, the research paper by Ebeke and Everaert (2014) performs OLS estimations for both gap and changes version of Okun's law for the countries Estonia, Latvia and Lithuania. This paper finds relatively high and sensitive Okun relationships for the Baltic states. Furthermore, the researcher make use of rolling regressions which unveils a downtrend in the Okun coefficients for these countries and found no evidence of a break in this trend during the global financial crisis of 2008.

3 Methodology and Data

Scientists researching Okun's law mainly use one of two methodologies, which were both introduced by Okun in 1962. These two methods are informally named the "gaps" version and the "changes" version. The "gaps" version is best described with formulas while explaining the variables that are being used. This version consists of a set of three formulas

$$1)\ U_t - U_t^* = \delta(E_t - E_t^*) + \mu_t\ , \delta < 0$$

$$2)\ E_t - E_t^* = \gamma(Y_t - Y_t^*) + \eta_t\ , \gamma > 0$$

$$3)\ U_t - U_t^* = \beta(Y_t - Y_t^*) + \epsilon_t\ , \beta < 0$$

where U_t is the unemployment rate, E_t is the log of employment, Y_t is the log of output and the * version of these variables indicate a long-run level or as some researchers call them the "natural" level. Of these three formulas, formula three is called Okun's law which can be derived by substituting formula 2) into formula 1). Note that because of this derivation we can say that $\beta = \delta\gamma$ and $\epsilon_t = \mu_t + \delta\eta_t$, meaning that the coefficient β, which signifies the correlation between unemployment and output, depends on the coefficients in the two equations that underlie Okun's law.

Past research has come up with different values for the coefficients of the three formulas. Research done by Ball et al. 2013 expect the value of the variable that quantifies the response of employment to output (γ) to be less than 1.5 in absolute value contrary to other researchers' expectations. Ball et al. argue that labor is a quasi-fixed factor. Companies accommodate short-run production changes in other ways than adjusting employment level since that is too costly. Instead, firms adjust the time worked per worker and the exertion level per worker (Ball, Leigh, & Loungani, 2013).

The same researchers also expect the coefficient δ to be smaller than one in absolute value. They argue that employment moves more than one-to-one with unemployment. They cite that Okun discussed that an increase in employment leads to higher returns to employment search. Combining these two expectations results in a value of β that is less than the value of γ which was already expected to be smaller than 1.5 in absolute value.

The error term ϵ_t in equation 3) consists of factors that shift the output-employment correlation. These factors cause abnormal changes in labor force participation or productivity per worker etc. The smaller the error term is, the better this version of Okun's law fits.

The difficult part of using the "gaps" version comes with estimating the values of U_t^* and Y_t^*. While there are different methods that can be used when estimating these variables, most research papers use the HP filter which smooths out the output and unemployment series. Some researchers dislike this method as they deem the HP filter to be problematic.

The second methodology mainly used for research on Okun's law is called the "changes" version

$$4) \frac{\Delta Y}{Y_t} * 100\% = \alpha + \beta \Delta U + \varepsilon_t$$

where Y stands for GDP, U stands for unemployment rate and Δ indicates the change from the previous period. Using this equation, coefficient β signifies the percentage point change in GDP growth for every percentage point increase in U. e.g., if β=-2 that means for every percentage point increase in U, GDP growth will decrease with two percentage points.

This research paper uses the "changes" version of Okun's law, because it does not include the unobservables U_t^* and Y_t^* which could have led to problems which in turn invalidate the results of this research, caused by the underlying properties and drawbacks of the HP-filter. Researcher James Hamilton addresses this filter in his article "*Why You Should Never Use the Hodrick-Prescott Filter"*. In this article Hamilton raises the possible issues that can arise when using the HP filter. Using mathematical derivations, the researcher proves that this filter introduces spurious dynamic relations, can lead to filtered values which differ depending on their location in the sample and produces values for the smoothing parameter which are at odds with common practice (Hamilton, 2018). Considering these drawbacks, this paper decides to use the "changes" version.

This paper estimates Okun's law using quarterly data from the OECD looking at three groups of countries. The first group is Western Europe, which consists of Austria, Belgium, Germany, Denmark, Spain, France, United Kingdom, Ireland, Italy, Netherlands, Norway, Portugal and

Sweden. The second group is Eastern Europe, which consists of Czech Republic, Estonia, Finland, Greece, Hungary, Lithuania, Latvia, Poland, Slovak Republic and Slovenia. The last group is called “Global Countries”, which is a combination of two countries from all other continents except Africa. These countries are Australia, Canada, Chile, Colombia, Costa Rica, Israel, Japan, South Korea, Mexico, New Zealand, Turkey and USA. All data used will be from the OECD from the years 1980 to 2020.

I perform the “changes” version three times on the quarterly, annual and 3-year time frequency by using quarterly data and constructing the annual and 3-year moving averages. The use of these moving averages captures two ideas, one is that new employees need to be trained for a period of time before they significantly increase the production. This idea is based on the fact that countries differ in their proportion of skilled to unskilled labor. We know that countries in Western Europe have a higher skilled to unskilled labor ratio as compared to other countries in the world and thus I expect the moving averages to explain more of the variance of GDP growth for Western Europe as compared to other regions. The second captured idea is that firms will wait and see how a recession develops before making employment adjustments and only start laying off workers several months into a recession. I will compare the different time frequencies in order to know which version of Okun’s law fits better.

I also perform the changes version of Okun’s law on industries to see which industries have a stronger Okun relationship. This can help explain why for certain countries the Okun relationship is stronger as compared to others since countries differ in their GDP composition per industry. Since I regress GDP growth on employment instead of unemployment, I expect positive values for the Okun coefficients. This will be done using annual GDP growth and employment change data from Eurostat of the European Union including the United Kingdom from the years 1996 to 2019 for the following industries: Agriculture, forestry and fishing (AFF); Industry expect construction (IND); Manufacturing (MAN); Construction (CON); Wholesale and retail trade, transport, accommodation and food service activities (WRT); Information and communication (INF); Financial and insurance activities (FIN); Real estate activities (REA); Professional, scientific and technical activities, administration and support service activities (PCT); Public administration, defense,

education, human health and social work activities (PUB); Arts, entertainment and recreation (AER).

The formula used to analyze this relationship will look like the following

$$5)\ \frac{\Delta Y}{Y_t} * 100\% = \alpha + \beta \frac{\Delta E}{E_t} * 100\% + \varepsilon_t$$

The only difference between equation 5) and 4) is that I use employment percent change instead of unemployment rate change. Since I use employment data, I expect the coefficient to have a positive value.

4 Results

I first estimate the quarterly Okun coefficients of Western Europe, followed by the annual moving average Okun coefficients and the 3-year moving average Okun coefficients. After which I move on to Eastern Europe, and subsequently estimate the Okun coefficients for at least two countries from all other continents. This last group is titled as “Global Countries”.

Western Europe

Quarterly Okun Estimations

The estimations are based on 13 countries with unemployment rate change and GDP growth data from 1983-Q1 and 2019-Q1. Table 1 reports the estimated results across Western European countries. The quarterly Okun coefficients fall in the range between -1.47 and 0.15, of which three out of thirteen are not statistically significant at the 95% confidence interval (Germany, Spain, and Norway).

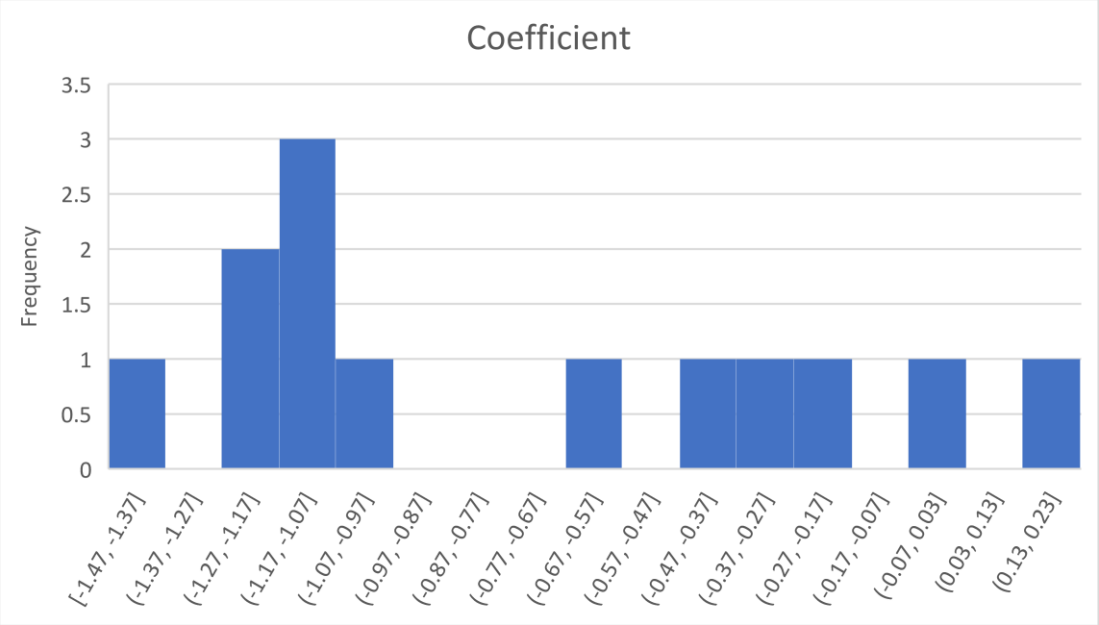
Table 1 Estimates of Quarterly Okun Coefficients for Western Europe

Country	Coefficient	P-value	R-squared	Observation
Austria	-0.386	0.004	0.085	105
Belgium	-0.347	0.015	0.042	144
Germany	0.151	0.222	0.018	113
Denmark	-1.160	0.000	0.109	144
Spain	0.000	0.900	0.000	132
France	-1.136	0.000	0.270	144
United Kingdom	-1.252	0.000	0.248	144
Ireland	-1.478	0.002	0.065	144
Italy	-0.598	0.009	0.056	144
Netherlands	-1.186	0.000	0.123	144
Norway	-0.252	0.264	0.011	121
Portugal	-1.151	0.000	0.192	144
Sweden	-1.057	0.000	0.147	144

Two out of the three insignificant Okun coefficients are positive in value, establishing for quarterly estimations that the relationship between GDP growth and unemployment rate change tends to be negative. Figure 1 displays the histogram for the estimated quarterly Okun coefficients, which have an average value of -0.75. The average value becomes equal

to -0.97 when leaving out the statistically insignificant coefficients. The standard deviation is equal to 0.52.

Figure 1 Histogram of the Quarterly Okun Coefficients of Western Europe



Annual Moving Average Okun Estimations

The annual moving average estimations are based on the same 13 countries with unemployment rate change and GDP growth data from 1983-Q1 to 2019-Q1. However, since we estimate the annual moving average coefficients, we lose three quarters of datapoints in order to calculate the annual moving average properly. Table 2 reports the estimated results

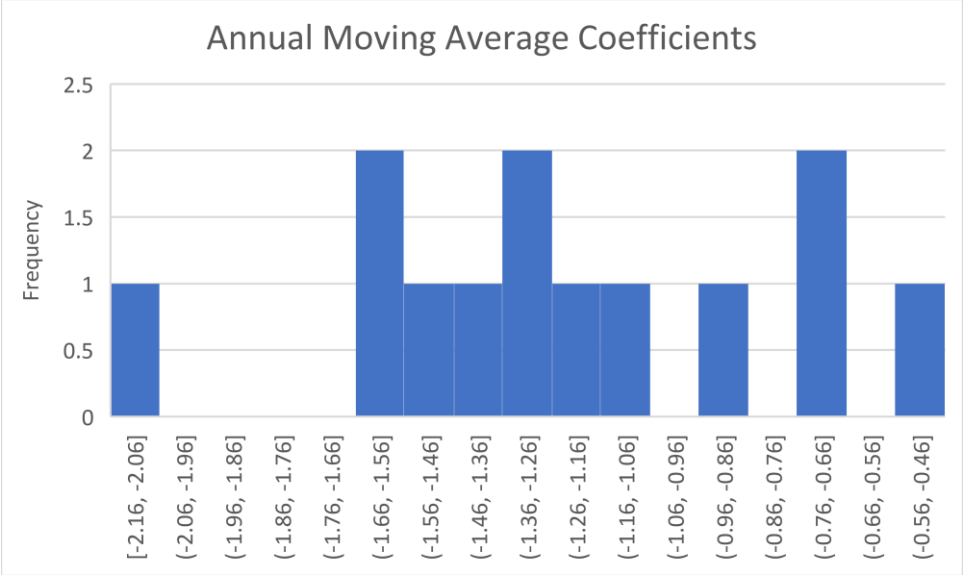
across countries. The Okun coefficients fall in the range of -2.16 and -0.49, with all coefficients being statistically significant at the 95% confidence interval.

Table 2 Estimates of Annual Moving Average Okun Coefficients of Western Europe

Country	Coefficient	P-value	R-squared	Observations
Austria	-1.182	0.000	0.234	102
Belgium	-0.877	0.000	0.221	141
Germany	-0.680	0.001	0.102	110
Denmark	-1.621	0.000	0.504	141
Spain	-0.491	0.000	0.337	129
France	-1.337	0.000	0.412	141
United Kingdom	-1.620	0.000	0.490	141
Ireland	-2.160	0.000	0.430	141
Italy	-1.130	0.000	0.181	141
Netherlands	-1.448	0.000	0.396	138
Norway	-0.665	0.003	0.074	118
Portugal	-1.344	0.000	0.429	141
Sweden	-1.506	0.000	0.480	141

The estimations reveal a negative relationship for all chosen Western European countries in this time frequency. The annual moving average coefficients are also higher in absolute value for all 13 countries when comparing them to the quarterly coefficients. Figure 2 displays the histogram for the estimated annual moving average Okun coefficients. The estimated coefficients have an average value of -1.24 with a standard deviation of 0.45.

Figure 2 Histogram of the Annual Moving Average Okun Coefficients for Western Europe



3-Year Moving Average Okun Estimations

Estimations are based on the same data as the previous two categories, with the removal of 11 previous quarters in order to properly calculate the 3-year moving average values of the unemployment rate change and GDP growth. Table 3 reports the estimated results across countries. The 3-year moving average Okun coefficients fall in the range of -2.50 and -0.66, with once again all of the coefficients being statistically significant.

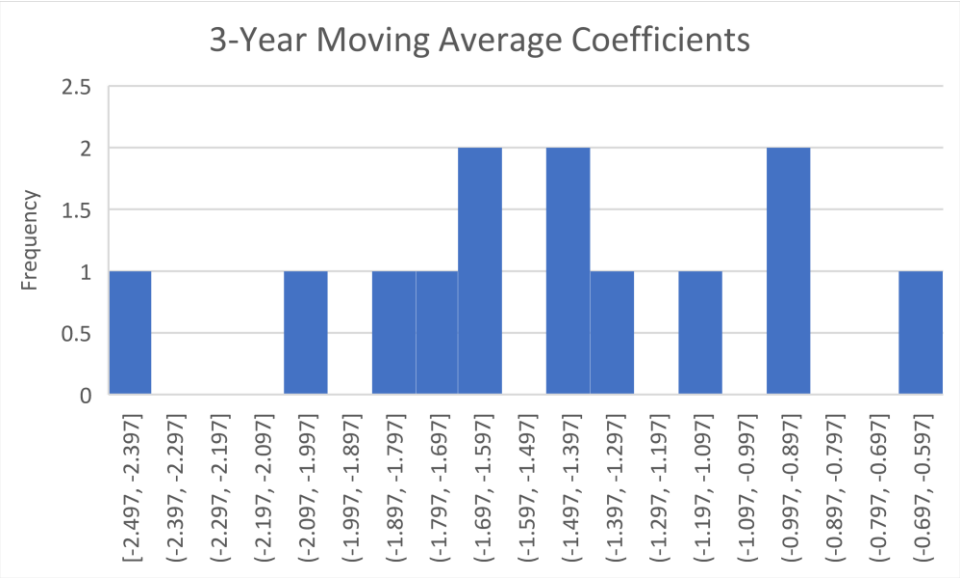
Table 3 Estimates of the 3-Year Moving Average Okun Coefficients for Western Europe

Country	Coefficient	P-value	R-squared	Observations
Austria	-1.801	0.000	0.241	91
Belgium	-0.931	0.000	0.355	130
Germany	-0.658	0.000	0.154	99
Denmark	-1.689	0.000	0.705	130
Spain	-0.899	0.000	0.722	118
France	-1.450	0.000	0.416	130
United Kingdom	-1.712	0.000	0.595	130
Ireland	-2.497	0.000	0.782	130
Italy	-1.130	0.000	0.218	130
Netherlands	-1.643	0.000	0.550	127
Norway	-2.056	0.000	0.352	107
Portugal	-1.439	0.000	0.468	130
Sweden	-1.377	0.000	0.608	130

Likewise, all coefficient values for the 3-year time frequency are negative in value with all countries having larger absolute coefficient values when comparing these estimates with the quarterly estimates. Figure 3 displays the histogram of the estimated 3-year moving average Okun coefficients, which have an average value of -1.48 and a standard deviation of 0.48.

The average value for the 3-year time frequency seems to be larger in absolute value in comparison with both the quarterly time frequency and the annual time frequency.

Figure 3 Histogram of the 3-Year Moving Average Okun Coefficients for Western Europe



Overall Comparison of the Western Europe Estimations

The quarterly estimations report an average Okun coefficient value of -0.75 for Western Europe. So, on average, Okun's law seems to hold in this world region. However, not all 13 chosen countries have an Okun coefficient that is negative in value. Germany has an Okun coefficient of 0.15, meaning that an increase in unemployment is correlated with an increase in GDP growth. The country of Spain has a fairly interesting Okun coefficient with it being equal to 0.00 which suggests that there is no linear relationship between GDP growth and unemployment rate change. These estimations do report higher p-values for both these countries indicating an insignificant Okun coefficient value. The only other country having an insignificant Okun coefficient value is Norway which coincidentally also had the weakest Okun relationship of the chosen countries who displayed a negative relationship between GDP and unemployment. The country with the strongest Okun coefficient at the quarterly time frequency is Ireland which had an Okun coefficient value of -1.47.

When looking at the annual moving average estimations, the estimations display much stronger Okun relationships for all 13 Western European countries, with all Okun coefficients

being statistically significant at the conventional 5% level. Literally every country reports a stronger Okun coefficient when comparing the annual moving average with the quarterly estimations. Even the countries Germany and Spain have a Okun coefficient which is negative in value. And all three countries which had statistically insignificant Okun coefficients, now have statistically significant Okun coefficients at the 95% confidence interval. These three countries report the weakest Okun coefficients at this time frequency, with Spain reporting the weakest Okun relationship with a coefficient value of -0.49. The average Okun coefficient value turns from -0.75 for quarterly estimations to -1.24 for annual moving average estimations, which is quite the jump.

For Western Europe, the estimates report much stronger Okun relationships at longer time frequencies (3-year) in comparison with shorter time frequencies (quarterly). The average Okun coefficient value for this world region at the 3-year time frequency is twice as big as the average Okun coefficient value for this world region at the quarterly time frequency. Meaning that the correlation between GDP growth and unemployment rate change is much stronger over longer period of time rather than shorter period of times. When comparing the annual moving average Okun coefficients with the quarterly Okun coefficients, the estimate report stronger Okun relationships for all 13 Western European countries. The Okun coefficients of Germany and Spain, which were positive in value for the quarterly estimations, turned negative in value when using the annual and 3-year moving average estimations. Establishing that Okun's law also holds for these countries as long as the data takes long term approach. Even when comparing the 3-year moving average estimations with the annual moving average estimations, the estimations display stronger Okun coefficient values. However, not all 13 countries display stronger Okun relationship when comparing the 3-year moving average with the annual moving average estimations. This is case for Germany, Italy and Sweden. One country that has very interesting estimation report is Norway, which had the weakest Okun relationship that is negative in value for the

quarterly estimations and also the second strongest Okun relationship for the 3-year moving average estimations.

Eastern Europe

Quarterly Okun Estimations

The estimations are based on 10 countries with GDP growth and unemployment rate change data from 1988-Q1 to 2019-Q4. Table 4 reports the estimated results across Eastern European countries. The quarterly Okun coefficients fall in the range of -1.31 and -0.40 with all coefficients being statistically significant at the 95% confidence interval.

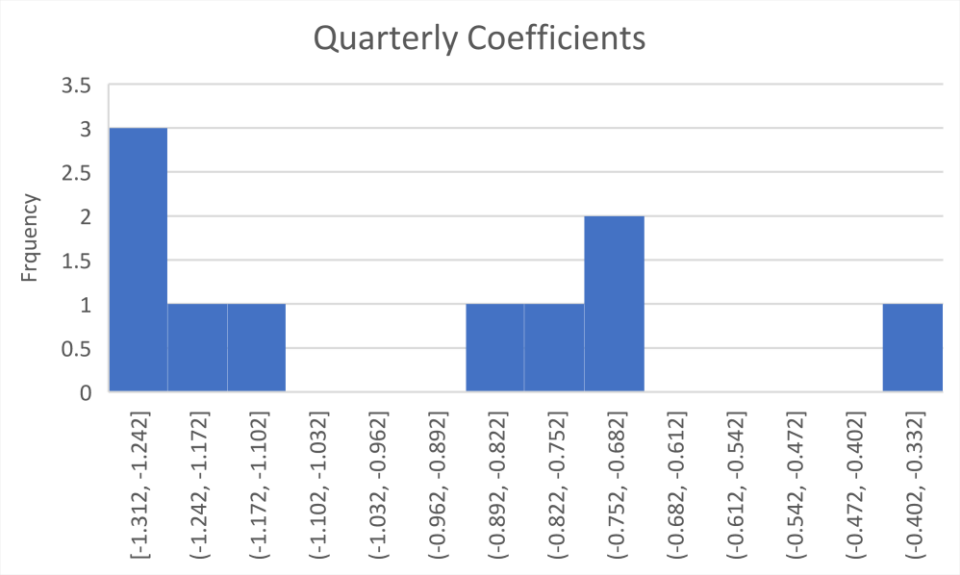
Table 4 Estimates of Quarterly Okun Coefficients for Eastern Europe

Country	Coefficient	P-value	R-squared	Observations
Czech Republic	-1.265	0.000	0.228	103
Estonia	-0.760	0.000	0.139	91
Finland	-1.261	0.000	0.254	127
Greece	-1.312	0.000	0.295	86
Hungary	-0.707	0.002	0.095	95
Lithuania	-1.191	0.000	0.291	95
Latvia	-0.887	0.000	0.154	86
Poland	-0.400	0.024	0.056	91
Slovak Republic	-1.141	0.000	0.141	87
Slovenia	-0.746	0.013	0.065	95

All 10 chosen Eastern European countries have negative Okun coefficients, establishing further proof of a negative relationship between GDP growth and unemployment rate change. Figure 4 displays the histogram for the estimated quarterly Okun coefficients. The

estimated coefficients have an average value of -0.97 with a standard deviation equal to 0.29.

Figure 4 Histogram of the Quarterly Okun Coefficients of Eastern Europe



Annual Moving Average Okun Estimations

The estimations are based on the same 10 countries using unemployment rate change and GDP growth data from 1983-Q1 to 2019-Q1. Three observations are lost in order to estimate the annual moving average. Table 5 reports the estimated results across Eastern European

countries. The Okun coefficients fall in the range of -2.11 and -0.37, with all coefficients being once again statistically significant at conventional levels.

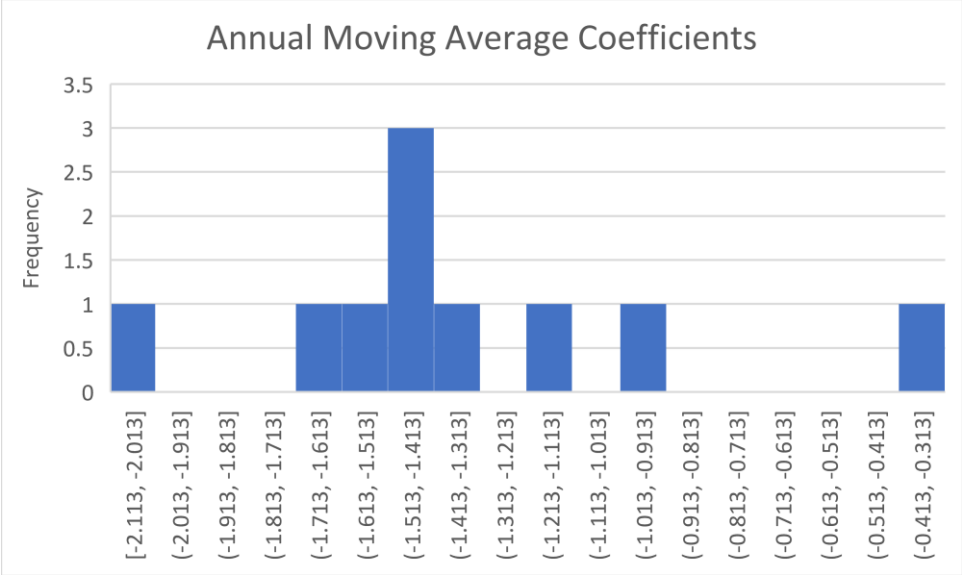
Table 5 Estimates of the Annual Moving Average Okun Coefficients of Eastern Europe

Country	Coefficient	P-value	R-squared	Observations
Czech Republic	-1.538	0.000	0.382	100
Estonia	-1.402	0.000	0.449	88
Finland	-1.464	0.000	0.502	125
Greece	-1.457	0.000	0.529	83
Hungary	-1.197	0.000	0.188	92
Lithuania	-1.492	0.000	0.627	83
Latvia	-1.707	0.000	0.610	83
Poland	-0.371	0.000	0.167	88
Slovak Republic	-0.955	0.000	0.298	84
Slovenia	-2.113	0.000	0.395	92

The coefficients reveal a stronger negative relationship between GDP growth and unemployment rate change for Eastern Europe at the annual time frequency in comparison with the quarterly time frequency, however not all 10 countries display a stronger Okun relationship. Figure 5 displays the histogram for the estimated annual moving average Okun

coefficients. The estimated coefficients have an average value of -1.37 with a standard deviation of 0.44.

Figure 5 Histogram of the Annual Moving Average Okun Coefficients for Eastern Europe



3-Year Moving Average Okun Estimations

The 3-year moving average estimations are based on the same dataset, however 11 observations are not included in order to properly calculate the 3-year moving average GDP growth and unemployment rate change. Table 6 reports the estimated results across

countries. The 3-year moving average Okun coefficients fall in the range of -2.40 and -0.38 with all coefficients being statistically significant.

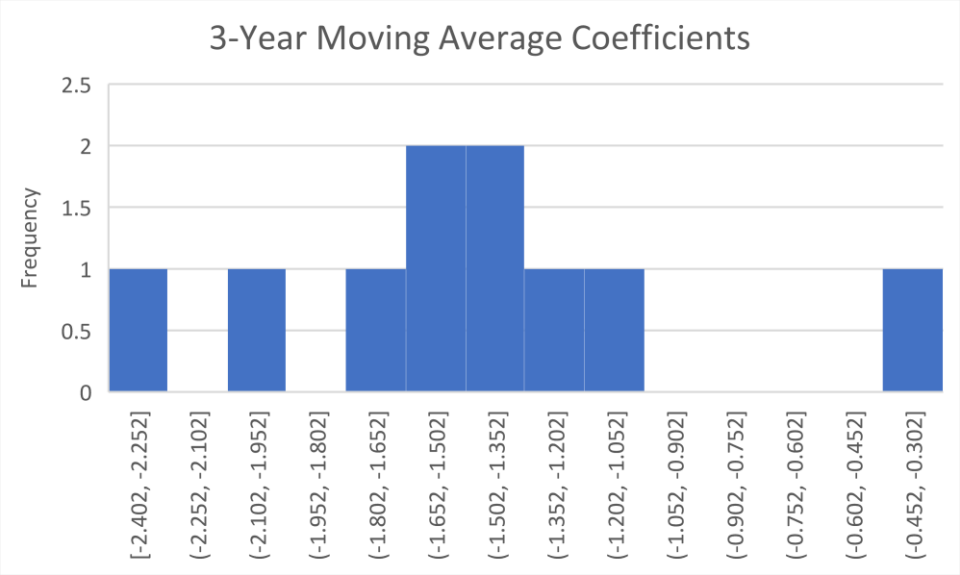
Table 6 Estimates of the 3-Year Moving Average Okun Coefficients for Eastern Europe

Country	Coefficient	P-value	R-squared	Observations
Czech Republic	-1.542	0.000	0.395	92
Estonia	-1.630	0.000	0.535	80
Finland	-1.431	0.000	0.633	117
Greece	-1.668	0.000	0.656	75
Hungary	-1.319	0.000	0.273	84
Lithuania	-1.484	0.000	0.740	75
Latvia	-1.986	0.000	0.622	75
Poland	-0.380	0.000	0.348	80
Slovak Republic	-1.096	0.000	0.431	76
Slovenia	-2.402	0.000	0.586	84

The estimates once again reveal a negative relationship between GDP growth and unemployment rate change for all 10 countries at the 3-year time frequency. The coefficients have an average value of -1.49 and a standard deviation of 0.51. The average value for the 3-year moving average coefficients is higher in comparison with both the

quarterly and annual time frequencies, however not all countries display a stronger relationship when comparing the 3-year moving average with the annual moving average.

Figure 6 Histogram of the 3-Year Moving Average Okun Coefficients for Eastern Europe



Overall Comparison of the Eastern European Estimations

The quarterly estimations of Eastern Europe report negative coefficient values for all 10 chosen countries, establishing that Okun's law holds for this world region at short time frequencies. The average Okun coefficient value of this world region for the quarterly time frequency equals -0.97 which is bigger in absolute value when comparing it with the average Okun coefficient value of Western Europe using quarterly estimations. The quarterly estimations of Eastern Europe have the lowest standard deviation of 0.29 meaning that this category has coefficient value which are closest to one another in terms of value. The country with the highest Okun coefficient value for the quarterly time frequency is Greece with an Okun coefficient value equal to -1.31. The country with the lowest Okun coefficient value for this time frequency, which also is the only country with a statistically insignificant coefficient is Poland with a coefficient value equal to -0.4.

The estimation reports of Poland are quite interesting, in the fact that the Okun coefficient value of this country does not change much at all when using different time frequency. The coefficient value changes into -0.37 for the annual moving average estimations and into -0.38 for the 3-year moving average estimations. This means that relationship between GDP growth and unemployment rate change is the same for Poland when using different time

frequencies. A case study looking into Okun's law for Poland under different time frequencies and time periods would be quite interesting.

When comparing the annual moving average estimations with the quarterly estimations, the tables display stronger Okun relationships for all countries except for Poland and Slovakia. The country with the strongest annual moving average Okun relationship is Slovenia with a Okun coefficient value of -2.11, which also had the highest jump in terms of coefficient value when comparing the annual moving average coefficient with the quarterly coefficient. Another country making a remarkable jump in terms of coefficient value is Latvia, which had a quarterly Okun coefficient value of -0.89 which turned into -1.71 and -1.99 for the longer time frequencies. All 10 chosen Eastern European countries display statistically significant coefficients at this time frequency. The average annual moving average Okun coefficient for Eastern Europe is equal to -1.37 which establishes a stronger annual moving average Okun relationship for Eastern Europe in comparison with Western Europe.

The 3-year moving average estimations have an average value of -1.49 which is surprisingly close to the average value of West Europe at this time frequency, which is -1.48. The country with the strongest Okun coefficient value is once again Slovenia with a coefficient value of -2.40. The country with the weakest Okun relationship is, as mentioned before, Poland with a coefficient value of -0.38. For Eastern Europe, all 10 chosen countries report negative Okun coefficient values for all three time frequencies, establishing that Okun's law holds and is valid for this world region. Another fact that is established is stronger Okun relationships for longer time frequencies.

Global Countries

Quarterly Okun Estimations

The Global countries estimations are based on two countries from each continent (except Europe). The chosen countries are the USA and Canada, Chile and Colombia, Costa Rica and Mexico, Israel and Turkey, South Korea and Japan, Australia and New Zealand representing North America, Latin America, Middle America, Middle East, Asia and Oceania respectively. The dataset ranges from 1983-Q1 to 2020-Q1. Table 7 reports the estimated results across Global countries. The quarterly Okun coefficients fall in the range of -3.69 and 0.35 with two

coefficients not being statistically significant at the 95% confidence interval (Israel and New Zealand).

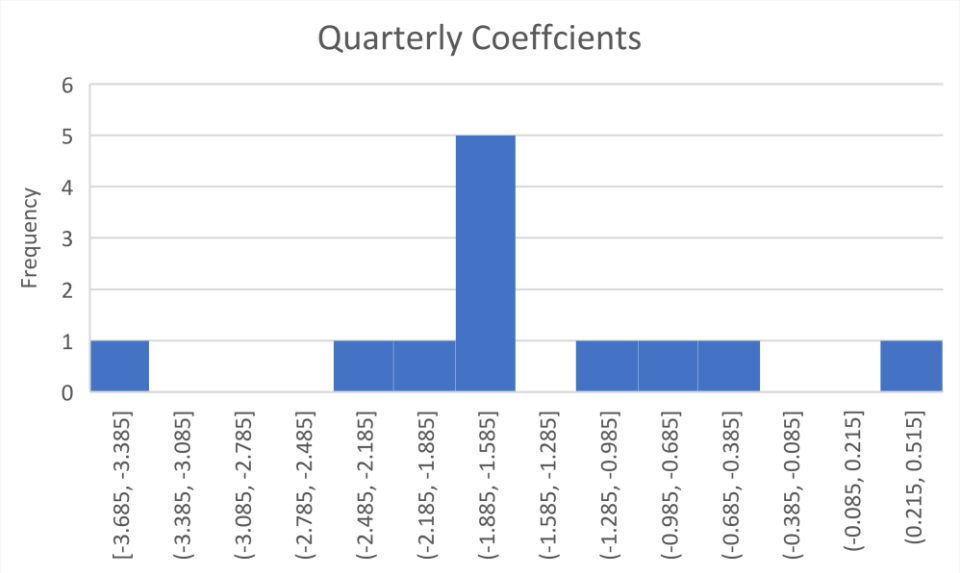
Table 7 Estimates of Quarterly Okun Coefficients of Global Countries

Country	Coefficient	P-value	R-squared	Observations
Australia	-1.585	0.000	0.253	152
Canada	-1.840	0.000	0.797	153
Chile	-1.898	0.000	0.401	104
Colombia	-1.815	0.000	0.860	56
Costa Rica	-0.747	0.000	0.744	42
Israel	-0.563	0.167	0.019	104
Japan	-1.617	0.043	0.027	152
South Korea	-1.864	0.000	0.272	125
Mexico	-3.685	0.000	0.287	137
New Zealand	0.354	0.376	0.006	135
Turkey	-2.273	0.001	0.158	64
USA	-1.126	0.000	0.769	153

Coincidentally, only New Zealand displays a positive relationship between GDP growth and unemployment rate change, establishing a mostly negative relationship for Global countries.

Figure 7 displays the histogram for the estimated quarterly Okun coefficients, which have an average value of -1.55 with a standard deviation equal to 0.95.

Figure 7 Histogram of the Quarterly Okun Coefficients of Global Countries



Annual Moving Average Okun Estimations

The estimations are based on the same 12 countries using the same GDP and unemployment rate dataset. However, the estimations lose three quarters of datapoints in order to properly calculate the annual moving average for both GDP growth and unemployment rate change. Table 8 reports the estimated results across this group. The Okun coefficients fall in the

range of -3.00 and -0.29, with only Costa Rica not having a statistically significant Okun coefficient.

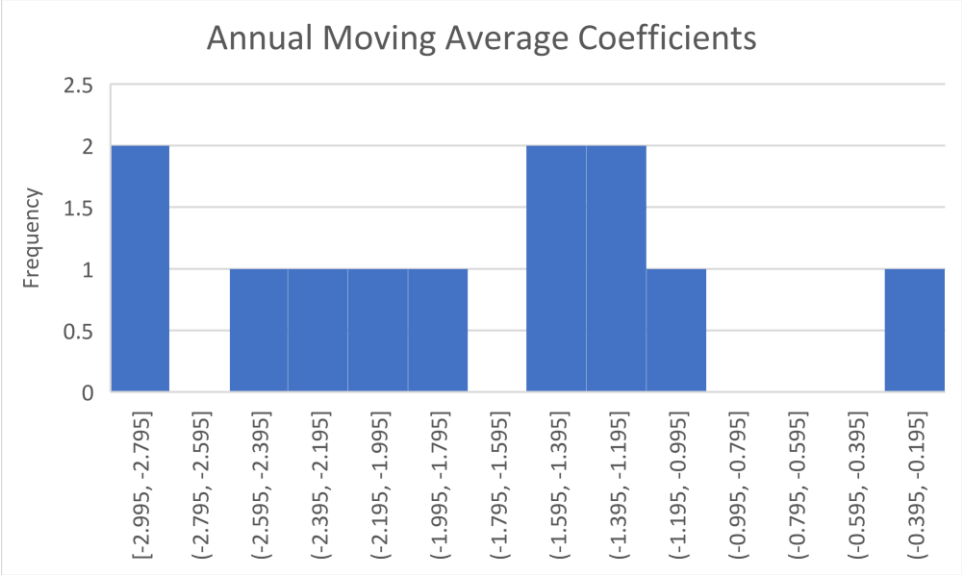
Table 8 Estimates of Annual Moving Average Okun Coefficients of Global Countries

Country	Coefficient	P-value	R-squared	Observations
Australia	-1.180	0.000	0.396	141
Canada	-1.981	0.000	0.678	141
Chile	-1.533	0.000	0.481	96
Colombia	-2.506	0.000	0.613	48
Costa Rica	-0.288	0.183	0.055	34
Israel	-1.227	0.000	0.237	93
Japan	-2.995	0.000	0.189	141
South Korea	-2.154	0.000	0.446	113
Mexico	-2.871	0.000	0.595	125
New Zealand	-1.531	0.000	0.535	127
Turkey	-2.326	0.000	0.608	53
USA	-1.375	0.000	0.560	141

The estimations reveal a negative relationship between GDP growth and unemployment rate change for all 12 chosen countries, establishing the fact that Okun's law holds for this group at the annual time frequency. Figure 8 displays the histogram for the estimated annual

moving average Okun coefficients. The estimated coefficients have an average value of -1.83 with a standard deviation of 0.75.

Figure 8 Histogram of the Annual Moving Average Okun Coefficients of Global Countries



3-Year Moving Average Okun Estimations

Estimations are based on the same dataset as the previous two time frequencies, however 11 previous quarters are not included in order to properly calculate the 3-year moving average values. Table 9 reports the estimated results across Global countries. The 3-year

moving average Okun coefficients fall in the range of -2.76 and -0.26, with all coefficients being statistically significant at conventional levels except for the coefficient of Costa Rica.

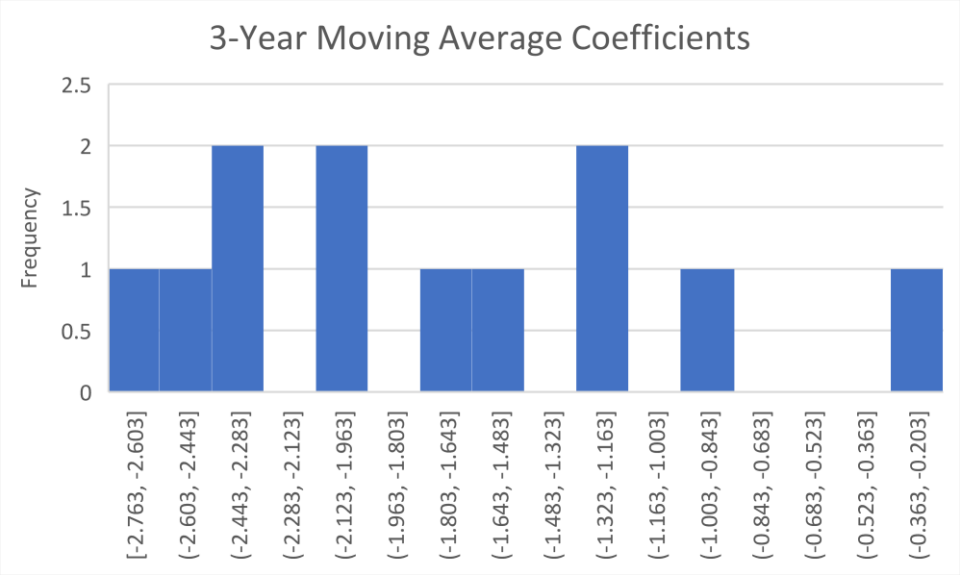
Table 9 Estimates of the 3-Year Moving Average Okun Coefficients of Global Countries

Country	Coefficient	P-value	R-squared	Observations
Australia	-1.304	0.000	0.669	130
Canada	-2.003	0.000	0.777	130
Chile	-1.724	0.000	0.505	96
Colombia	-2.763	0.000	0.774	37
Costa Rica	-0.263	0.289	0.051	24
Israel	-0.889	0.000	0.162	86
Japan	-2.413	0.000	0.142	130
South Korea	-1.516	0.000	0.194	105
Mexico	-2.513	0.000	0.614	117
New Zealand	-2.070	0.000	0.889	122
Turkey	-2.306	0.000	0.573	45
USA	-1.163	0.000	0.462	130

Table 9 only reports negative Okun coefficient values, establishing that Okun's law also holds for Global countries at the 3-year time frequency. Figure 9 displays the histogram of the

estimated 3-year moving average Okun coefficients, which have an average value of -1.74 with a standard deviation of 0.71.

Figure 9 Histogram of the 3-Year Moving Average Okun Coefficients of Global Countries



Overall Comparison of the Global Countries Estimations

The quarterly estimations of the Global countries group report negative Okun coefficients for 11 countries, with only New Zealand having a positive relationship between GDP growth and unemployment rate change. New Zealand is also the only country having a statistically insignificant Okun coefficient in the quarterly time frequency. The Okun coefficients in this category have the highest standard deviation of all categories, with it being equal to 0.95. The quarterly Okun coefficients have an average value equal to -1.55, which makes this group have the highest average value when comparing with both the European groups. The country with the strongest Okun relationship is Mexico with its Okun coefficient being equal to -3.69. Moreover, the quarterly Okun coefficient of Mexico is the largest Okun coefficient of all estimations in this paper.

The average value of the annual moving average Okun coefficients for this group is equal to -1.83. Just like the previous two world regions, the Global countries group saw an increase in average Okun coefficient value when comparing the quarterly with the annual moving average estimations. However, not all countries saw an increase in the strength of their Okun relationship. Australia, Chile, Costa Rica and Mexico all saw a decrease in their Okun coefficient. Furthermore, the coefficient of New Zealand became statistically significant at all

conventional levels, but in return, the estimations report a statistically insignificant Okun coefficient for Costa Rica. The country with the biggest change in their Okun coefficient was Japan, whose coefficient value was equal to -1.62 for the quarterly estimations and -3.00 for the annual moving average estimations, which was the highest Okun coefficient for this time frequency.

When looking at the 3-year moving average estimations, the estimations report something fairly interesting. The average Okun coefficient value of the 3-year moving average estimations are lower than the average Okun coefficient value of the annual moving average estimations. This was not the case for the European groups. So, for this group it seems as if Okun's law is stronger at annual time frequency in comparison with the 3-year time frequency. The average value of the 3-year moving average estimations is equal to -1.74. Costa Rica once again has a statistically insignificant Okun coefficient and coincidentally the lowest Okun coefficient value in absolute terms. The country with the highest Okun coefficient value for this time frequency is Colombia, with a coefficient value equal to -2.76.

Sectoral Okun Relationships

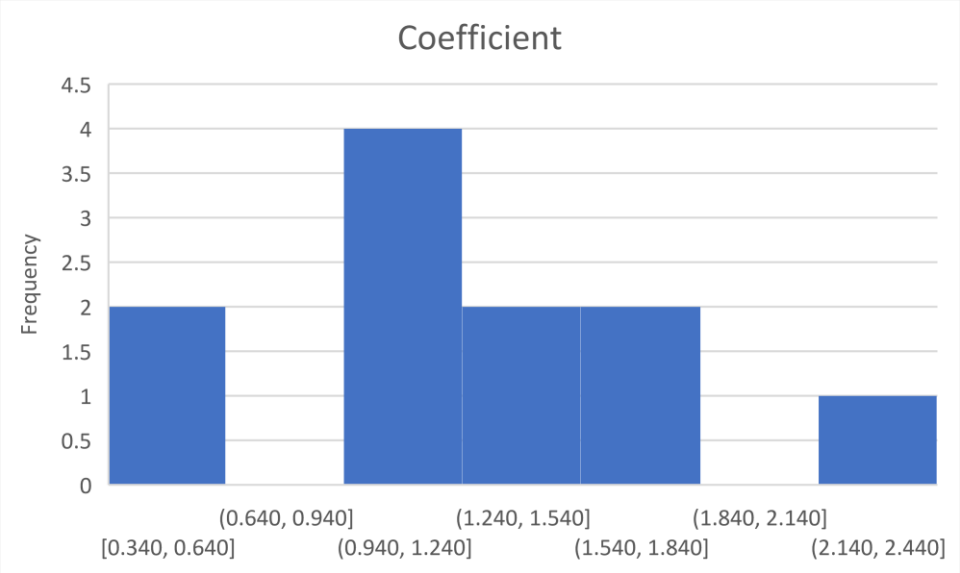
Another explanation as to why some countries display stronger Okun relationships than others could be the composition of GDP aggregates by industry. Some industries can have different GDP and employment relationships which can affect the Okun coefficient for those industries. The next part of the results shines light on the relationship between GDP growth and employment percentage change for the European Union including the United Kingdom. Using Eurostat data from 1996 till 2019 for eleven industries. Table 13 reports estimated results across industries. The estimated industry Okun coefficients fall in the range between 0.34 and 2.16, with three being statistically insignificant.

Table 13 Estimates of Sectoral Okun Relationships

Industry	Coefficient	P-value	R-squared	Observations
Agriculture, foresting and fishing	0.340	0.570	0.015	24
Industry (except construction)	1.203	0.012	0.256	24
Manufacturing	1.289	0.010	0.268	24
Construction	1.369	0.000	0.775	24
Wholesale and retail trade, transport, accommodation, food service	2.161	0.000	0.602	24
Information and communication	1.556	0.000	0.481	24
Financial and insurance activities	1.107	0.135	0.098	24
Real estate activities	1.195	0.000	0.466	24
Professional, scientific, technical, administrative and support service activities	1.561	0.000	0.759	24
Public administration, defence, education, human health and social work activities	0.508	0.419	0.030	24
Arts, entertainment, recreation, other service activities; activities of household and extra-territorial organizations and bodies	1.180	0.024	0.211	24

Figure 13 displays the histogram for the estimated sectoral Okun coefficients. The estimated coefficients have an average value of 1.22 with a standard deviation of 0.47. The mean of the R-squared value equals 0.36. The wholesale and retail trade industry seems to have the strongest Okun relationship, where a one percent increase of the employment change results in a 2.2 percent increase in GDP growth. The industries agriculture, fishing and forestry and public administration, defence, education, human health and social work activities seem to have the weakest Okun relationships at 0.34 and 0.51 respectively. All other sectoral Okun coefficients lie in the range between 0.94 and 1.56.

Figure 13 Estimates of Sectoral Okun Coefficients



Conclusion

Okun's law indicates a reverse relationship between GDP growth and unemployment change. If unemployment drops, this means we should expect an increase in GDP and vice versa. Using multiple standard "changes" versions on different time frequencies and world regions, this paper finds that Okun's law seems to hold for most countries in the sample set and there seems to be stronger and statistically more significant Okun relationships for longer time frequencies.

The relationship on the quarterly time frequency is valid and significant for a total of 31 out of the 35 analyzes countries. The quarterly analysis shows that Okun's law is weakest for Western Europe, followed by Eastern Europe and thus strongest for the group Global countries. The relationship between GDP growth and unemployment rate change is for the Global group more than twice as strong as for the Western European group. Could this finding be caused by the fact that Western Europe tends to have higher skilled labor and thus workers need to be trained for a certain amount of time before actually affecting production which leads to weaker Okun coefficients for the quarterly time frequency? I implore future research to look into this.

As for the annual time frequency, the analysis reports a significant valid Okun relationship for 34 out of 35 countries, with Costa Rica being the only one with an insignificant but still negative in sign Okun coefficient. Once again, the estimations report that the Global countries group display the strongest Okun relationship followed by the Eastern European countries and finally the Western European countries. The analysis also reports stronger Okun relationships for all three world regions when comparing the annual moving average estimates with the quarterly estimates establishing that Okun's law holds stronger at longer time frequencies. For the 3-year moving average estimates we find larger average Okun coefficients in absolute terms for Western Europe and Eastern Europe, however this is not the case for the group Global countries. For this time frequency the research finds significant and valid Okun coefficients for again 34 out of 35 countries, with Costa Rica left out. Costa Rica is coincidentally the country with the least number of observations. It is unclear as to why the average Okun coefficient for the group Global countries is smaller in absolute terms when comparing the 3-year moving average with the annual moving average estimates. Another plausible hypothesis that is opened up by the results of this paper is the fact of

vastly different Okun coefficients depending on world region. Western European countries tend to have lower Okun coefficient in comparison to countries from other continents. Could this be caused by the fact that Western European countries tend to be more socialist when it comes to economic policy? Socialist countries tend to react faster to changes in GDP and want to stabilize their GDP growth for which they have policies in place that aim to minimize the unemployment rate at all times. This is something future researchers could and should look into as this seems to an area of research that's highly relevant to governments and policymakers all over the world.

From the regression results of Okun's law of different industries I conclude that most industries seem to have Okun coefficient between 0.940 and 1.840. We have to keep in mind that these results stem from data from European countries and thus we should interpret the results as European results. Future research should expand on this by taking industry data from all around the world in order to test the external validity of Okun's law for industries from other parts of the world. It would be interesting to see if performing analysis on different data sets would also net us the same outliers such as agriculture, public services and wholesale and retail trade. Do countries of which the GDP is more composed of wholesale and retail output also have higher Okun coefficients? And do countries of which the GDP is more composed of agriculture and public institutions have lower Okun coefficients? Or are these European specific outliers?

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